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Developing an Analysis and Planning Framework for District-Level Fuels Treatment Projects (Final Project Report)

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Final Project Report

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1. Summary

Widespread fuel reduction programs have been initiated in many parts of the USA in response to a growing threat of wildland fire. Urban encroachment, fuels buildup from fire suppression, and drought all have been linked to increasing wildfire frequency and severity. Developing effective mitigation strategies is a challenging problem, especially on vast tracts of federally-managed wildlands in the western U.S. Fuel reduction activities on Federal lands are generally difficult to plan and implement due to cost, public expectations, and land management regulations. State of the art wildfire modeling is frequently required to demonstrate the benefits of fuels reduction treatments and defend fuel management projects. Designing and testing fuel treatment scenarios is complex, and many metrics, including fire spread, intensity, expected loss, and other ecological risks must be analyzed. The problem is compounded by poor data integration among fire behavior models, desktop GIS, and Forest Service corporate data. .

In 2004 we proposed a 3-year project to the Joint Fire Science Program to streamline wildfire modeling for fuel management projects (Ager and McGaughey 2003). The project was funded for 1 year as a proof of concept, and subsequently funded for two additional years as in the original proposal. In the first phase of the project, we developed a library of macros using ArcObjects to integrate wildfire models and vegetation databases within ArcGIS. ArcFuels macros link vegetation and wildfire behavior models with MS-Access, Excel, and Forest Service vegetation databases, greatly improving the capability for real-time evaluation of proposed fuel treatments within ArcGIS. The macros automated much of the spatial analysis and wildfire modeling required in the Fireshed process (Bahro et al. 2006) and the SPOT Pilot program (Gercke and Stewart 2006, http://www.nifc.gov/spots/).

In the second phase of the project, we focused on case studies and technology transfer. Substantial in-kind support was received from WO Wildfire RDA project headed by John Szymoniak, and the Western Wildland Environmental Threat Center in Prineville, OR. A contract programmer (John Anderson, BalanceTech, Missoula, MT) was employed to streamline the code and add functionality. A website was built (www.fs.fedf.us/pnw/arcfuels) and a number of hands-on workshops were conducted in Oregon and California with attendees from all Federal land management agencies. ArcFuels was adopted as the framework for the Fireshed and Stewardship Assessment program in Region 5. We developed an accelerated workshop format in Central Oregon where multiple projects are simultaneously analyzed in a workshop setting. This "RapidSpot" format is being further expanded to a national training in November 2007 in Portland, OR. Teams are being selected from all 10 Forest Service Regions and several

participants from other agencies will bring data from 13 fuel treatment projects to the workshop for analysis.

Parallel to the technology transfer efforts, we applied ArcFuels and related programs to develop a set of journal papers to demonstrate the integrated application of wildfire and vegetation models to address a number of science questions related to project level fuel treatment planning. Studies were published that examined longevity of fuel treatments, wildfire-bark beetle interactions, and the application of risk science to measure the performance of fuel treatment projects.

As the JFSP project ends, we are working to integrate ArcFuels into national level planning coursework and expanding ArcFuels functionality to advance the application of quantitative risk assessment in fuel treatment planning.

2. ArcFuels Description

Overview

The selection of models and linkages within the ArcFuels interface was aimed at providing the user with the following key functionality for fuels treatment planning: (1) an interactive system within ArcMap to develop stand-specific silvicultural prescriptions and fuel treatments within the Forest Vegetation Simulator (FVS, Dixon 2003), including thinning, underburning, and mechanical fuels treatment; (2) automated generation of data plots showing how stand fuel treatments change wildfires in terms of flame length, fire behavior, and stand mortality over time; (3) rapid scale-up of stand-specific treatments to simulate landscape-wide changes in vegetation and fuels from proposed management activities; (4) tight data linkages to FlamMap or FARSITE to simulate landscape-scale fire behavior and measure the treatment performance in terms of wildfire probabilities, spread rates, and fireline intensity (Finney 2004); (5) ability to easily modify and re-evaluate fuel treatment scenarios; and (6) integration of fire modeling spatial outputs into ArcGIS and other programs to facilitate the evaluation of fuel treatments with multi-resource objectives.

We used the ArcObjects library (Chang 2004) and Visual Basic for Applications (VBA, Pattison 1998) within ArcMap as the development framework. The VBA development interface is integrated within ArcMap and Microsoft (MS) Office products (Excel and Access). ArcFuels macros are distributed within ArcGIS project files (.mxd). The project file is loaded into ArcMap, and the macros appear as toolbars. Project defaults are stored in an MS Access database.

Stand Modeling of Fuel Treatments

Developing and testing treatment prescriptions for specific stands is an iterative process that seeks to find the best prescription to meet multiple objectives. The Forest Vegetation Simulator (FVS) and the FVS Fire and Fuels Extension (FFE, Reinhardt and Crookston 2003) are widely used to simulate thinning, prescribed fire, and mechanical treatment of downed fuels, and the post-treatment potential fire behavior. These simulations use a well-defined weather scenario, usually generated from field weather stations (http://www.fs.fed.us/raws/) using FireFamily Plus (USDA Forest Service 2002). Stand prescriptions are developed with a number of FVS keywords (for example THINSDI, SIMFIRE, FUELMOVE, see Dixon 2003). FVS and FFE can also be used to examine the longer term (for example 50 years) effects of the treatments on forest density and dead fuel dynamics provided a regeneration model is available.

We built an interface to FVS within ArcGIS to allow for rapid prescription development and testing. The *stand query* function was built into ArcFuels to allow users to interact with stand data and models within a GIS interface. Users can also load digital color imagery for their project area (http://www.apfo.usda.gov/NAIP.html) and stand polygon maps, and then test different management prescriptions by clicking on specific stands to execute one or more models. For instance, the stand can be processed with FVS to simulate management activities, forest growth, and potential wildfire behavior through time. The FVS Fire and Fuels Extension can simulate fire and fire-related mortality at the stand level using the SIMFIRE keyword (Reinhardt and Crookston 2003, p. 66). Potential wildfire behavior at the stand level can be modeled with the POTFIRE keyword (Reinhardt and Crookston 2003, p. 66). FVS outputs are generated in spreadsheet format using the FVS database extension (Crookston et al. 2006), and VBA macros generate Excel graphs of stand metrics, fuel loadings, and fire behavior through time. The treatments and simulated wildfire can then be visualized through time using the stand visualization system (SVS, McGaughey 2002) within ArcMap. Outputs for specific stands can be directly compared to color imagery. A direct link on the toolbar to the FVS prescription keywords allow for rapid changing of management prescriptions and testing of different fuel treatment options. The ArcFuels stand query function also builds input files for Nexus (Scott 1999) for performing rapid sensitivity analysis of fire behavior under different weather conditions. The system provides a rapid method for browsing a landscape in a spatial context, examining and visually validating the data representing the stand, and interatively testing stand level treatment prescriptions within GIS.

Landscape Design and Testing of Fuel Treatments

Landscape analysis of fuel treatment scenarios examines the aggregate effect of all treatments on potential wildfire behavior. The effects of fuel treatments on other landscape-scale goals are measured at this stage. Goals for wildlife, visuals, aquatics, and forest restoration may also be examined (Hayes and others 2004). Of key importance is the spatial arrangement and size of the fuel treatments relative to the direction of a likely wildfire event (Finney 2004). Testing the performance of fuels treatment strategies in terms of fire spread, travel time, and burn probabilities can be accomplished with the FlamMap program. The FVS Parallel Processing Extension can be used to model an array of treatment strategies that consider stand contagion, harvest constraints, and treatment goals (Finney et al 2006).

ArcFuels streamlines the process simulating landscape fuel treatments and builds the input files required by FlamMap. The assignment of treatment prescriptions to stands is accomplished in six ways: (1) ArcGIS selection; (2) stand query function; (3) database queries that key off data in the stand database; (4) importing a treatment optimization grid from FlamMap; (5) dynamic selection using FVS-PPE variable; and (6) external algorithms. In the latter, FVS-PPE can prioritize and constrain on multiple activities and land strata. This functionality was used to examine fuel treatment optimization (Finney and others 2006).

ArcFuels builds scenario files for the FVS-PPE from MS Access vegetation databases (Crookston and others 2006). Subsets of a landscape can be selected using the Select command in ArcMap, providing a simple method to interactively simulate landscape subunits or specific stand types (for example, select all stands within 200 meters of homes). FVS database outputs can be automatically joined to stand GIS coverages for rapid mapping of the simulation outputs. ArcFuels macros can be used to convert FVS database outputs to the binary landscape files required by FlamMap and FARSITE. This system can be used to generate sets of landscape files for multi-period and multi-scenario FVS simulations.

ArcFuels uses a database approach to organize management prescriptions for stands within a project area, and codes prescriptions within the stand database required by FVS (Crookston and others 2006). This simplifies the process of replicating complex constraints and management goals of multi-owner Firesheds. Key information about land management strata and other factors important for building management scenarios (for example, ownership, management emphasis) are stored in the FVS stand database.

Mapping Outputs

With the database extension, FVS outputs can be written to an Access database containing tables for stand summary statistics, potential fire behavior, fuels, and others (See Crookston and others 2004). A VBA script on the simulation interface joins these tables to the Arc feature class layer representing the stand polygons. Once joined, an array of map queries can be performed with ArcMap commands to create spatial displays of the FVS outputs. The joining of other databases can be automated by editing the underlying VBA macro.

Application with Landfire Data

ArcFuels routines were developed to allow for manipulation of Landfire data for fuel treatment planning. Landfire grids can be directly converted to FlamMap landscape files using a project mask to subset the Landfire tiles. Grids can be modified to reflect fuel treatments using a combined database-grid approach that provides a flexible way to target changes in the grids for specific treatment units. A grid substitution tool was built to make fast global changes in grid data. A number of other features were designed within ArcFuels to expedite fuel treatment planning with grid data.

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3. Deliverables

Selected Presentations and Abstracts

Ager, A. 2007. Overview of ArcFuels. GeoSpatial 2007, Building bridges to information sharing USDA/USDI. Portland, OR. (Presentation, Abstract)

Ager, A.; Kerns, B.; Finney, M.; Maffei, H. 2006. Assessing risk to biodiversity in the Pacific Northwest. Managing Biodiversity in Pacific Northwest Forests: Strategies and Opportunities. June 5-7, Portland, OR. (Abstract, Presentation)

Ager, A., Bahro, B. 2006. Using ArcObjects for Automating Fireshed Assessments and Analyzing Wildfire Risk. International ESRI Users Conference, San Diego, CA, August 7-11, 2006. (Abstract, Presentation).

Ager, A.; Finney, M. 2006. An Actuarial Approach to Modeling Wildfire Risk. Advances in threat assessment and their application to forest and rangeland management. Boulder, CO, July 18-20. (Abstract, Presentation)

Ager, A.; Finney, M.; McMahan, A. 2006. A wildfire risk modeling system for evaluating landscape fuel treatment strategies. 1st Fire Behavior and Fuels Conference, International Association of Wildland Fire, Portland, OR, March 28-30. (Abstract, Presentation)

Ager, A.; Bahro, B; and Barber, K. 2006. Automating the Fireshed process with ArcGIS. 1st Fire Behavior and Fuels Conference, International Association of Wildland Fire, Portland, OR, March 28-30.(Abstract, Poster)

Ager, A. 2006. ArcFuels. Forest Service Region 5 Fuels Planning Conference, Reno, NV, Feb. 2. (Abstract, Presentation)

Ager, A. 2005 ArcFuels: Forest planning tools for managing wildfire fuels. International ESRI Users Conference, San Diego, CA, August 2005. (Abstract, Presentation).

Ager, A. 2005. ArcFuels: Linking wildfire behavior and forest management models in ArcMap. U.S.Department of Agriculture, Forest Service, National Silviculture Workshop, Reno, NV. June 6-10. (Abstract, poster)

Ager, A. 2005. Tools for modeling fuels treatment alternatives at the project scale. Incorporating New Science into Hazardous Fuels and Vegetation Treatment Planning, Portland, OR, May 17-18. (presentation)

Ager, A. 2005. New GIS tools for landscape-scale fuels treatment planning. National Interagency Wildland Fuels Workshop, Atlanta, GA. April 18-20. (presentation, poster)

ArcFuels Workshops/Training

- 11/6/2007 (upcoming) National Rapidspot workshop. Approx. 50 attendees
- 2/7/2007, Forest Service Region 5 Fuel Planning and Management Specialists, Reno, NV. Workshop on fuel treatment planning. Approx. 45 attendees.
- 2/12/07, U.S. Geological Survey, Denver, CO, USGS Staff, Workshop on modeling wildfire behavior and landscape planning. Approx. 30 attendees.
- 3/14/2007 and 3/15/2007, Army National Guard, National Environmental Coordinators Training, San Diego, CA. Workshop on wildfire risk modeling. Approx. 120 attendees.
- 3/8/2007 and 3/9/2007 Central Oregon Fuel Planning and Management Specialists from USFS, Workshop on Fuel Treatment Planning and Wildfire Risk Assessment.
- 3/19/2007 and 3/20/2007, Fuel Planning and Management Specialists, Klamath National Forest, Yreka, CA. Approx. 30 attendees. Workshop on Fuel Treatment Planning and Wildfire Risk Assessment.

- 3/27/2007, Umatilla National Forest, Pendleton, OR, Fuel Planning and Management Specialists, Workshop on Fuel Treatment Planning and Wildfire Risk Assessment. Approx. 20 attendees.
- 4/10/2007 and 4/12/2007, Central Oregon Fuel Planning and Management Specialists from BLM, USFS, BIA, and The Nature Conservancy, Bend OR. Workshop on fuel treatment planning and wildfire risk assessment. Approx. 45 attendees

Publications

Ager, A.; Finney, M. (in press). A wildfire risk modeling system for evaluating landscape fuel treatment strategies. International Journal of Wildland Fire

Ager, A.; Kerns, B.; Finney, M.; Maffei, H. 2007. Modeling Wildfire Risk to Late Successional Forest Reserves in the Pacific Northwest, USA. Forest Ecology and Management 246:45-56

Ager, A.; Bahro, B.; Finney, M. A., 2006. Automating fireshed assessments and analyzing wldfire risk with ArcObjects and ArcGIS. Forest Ecology and Management 234S p S215.

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Technical papers

Ager, A. 2007. Operations Manual for ArcFuels. Available at www.fs.fed.us/pnw/wwetac/arcfuels

ArcFuels Website

www.fs.fed.us/pnw/wwetac/arcfuels

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